① TORA (Temporally Ordered Routing Algorithm)

- Create Route
- Erasing Route (create new route)
- Route Maintenance (If link break)

Concept of Height :

$$H = [\underbrace{\tau_i, oid, r_i}_{\text{Reference}}, \underbrace{\delta_i}_{\text{offset w.r.t refences}}, i]$$

τ = Time when link is broken

oid = Own Id (from where packet comes)

r = Reflection Bit (If nodes are of same height it updates 0,1)

reflected

orignal

δ = order to the node (If A → C preferred path A → B → C then δ tells the node to opt the same route)

i = Ids of node itself (pkt reach at dest)

Routing Protocol :

→ Each node other than the destination maintains its height w.r.t the destination.

→ Initially, the height of each node is set to "null".

$$H_i = (\_,\_,\_,\_,i)$$

→ Height of destination is always "0"

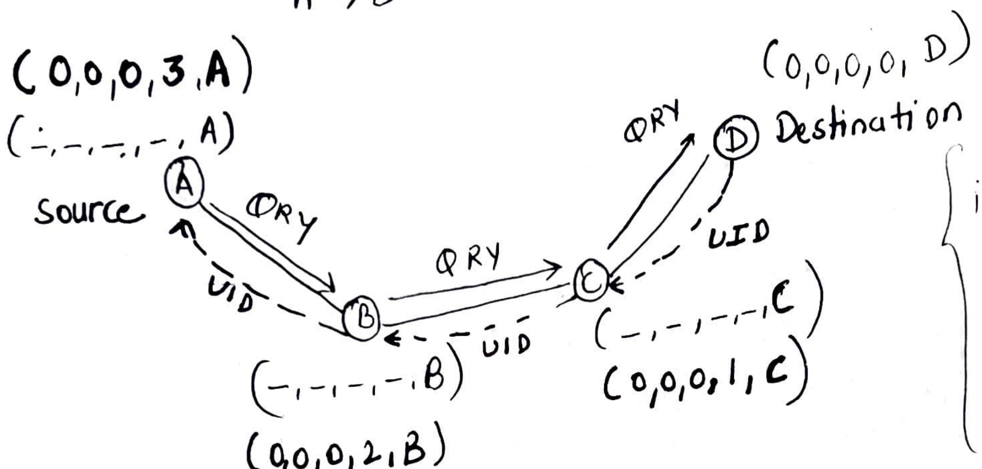
i.e

$$H_{dest} = (0, 0, 0, 0, dest)$$

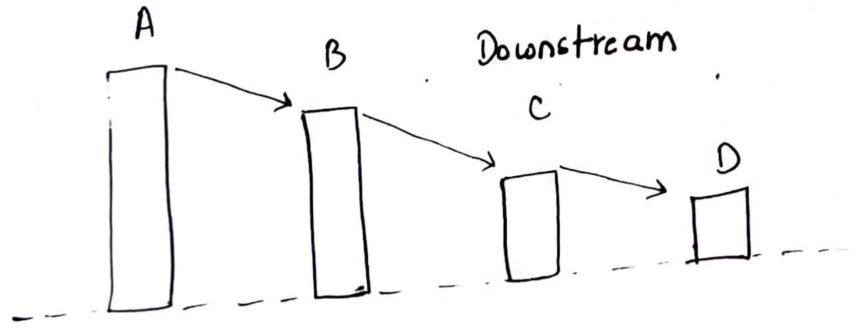
→ Each node maintains a height array for each neighbour.

Eg.

A → D



Once pkt is reached then destination sends a reply UID



∴ H of A > H of B > H of C > H of D

∴ Node A can send data to B

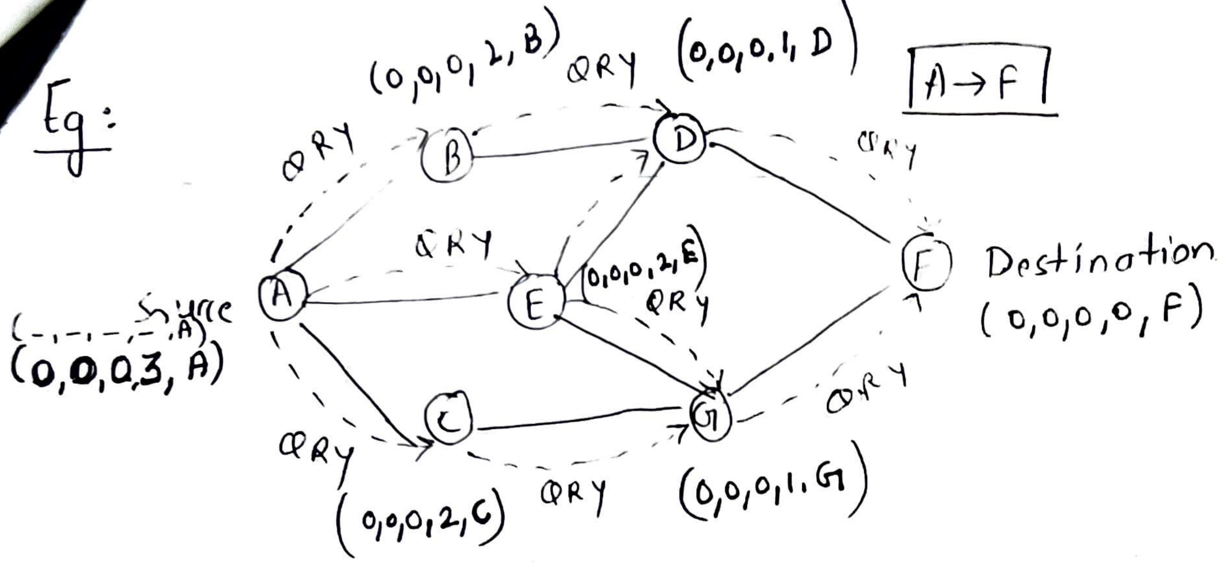
Node B " " " " C

Node C " " " " D

Data transmission occurs as

A → B → C → D

Eg:



∴ Height of A > Height of B, D, E, C, G

Downstream Routes:

Route 1: A → B → D → F

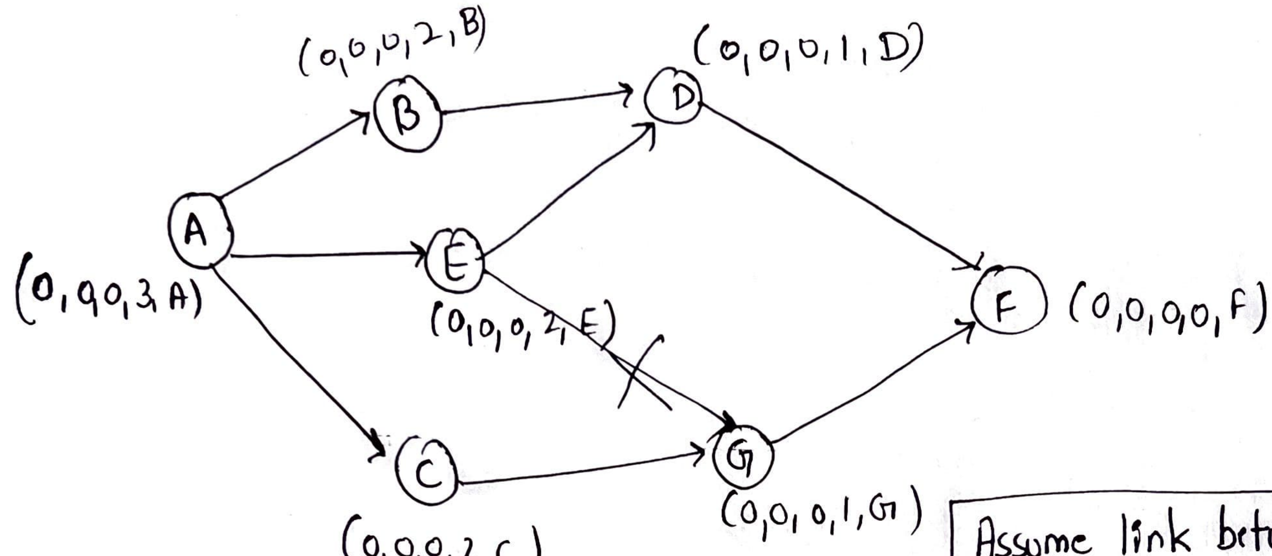
Route 2: A → E → G → F

Route 3: A → C → G → F

(Route Creation phase)

Route Maintainance

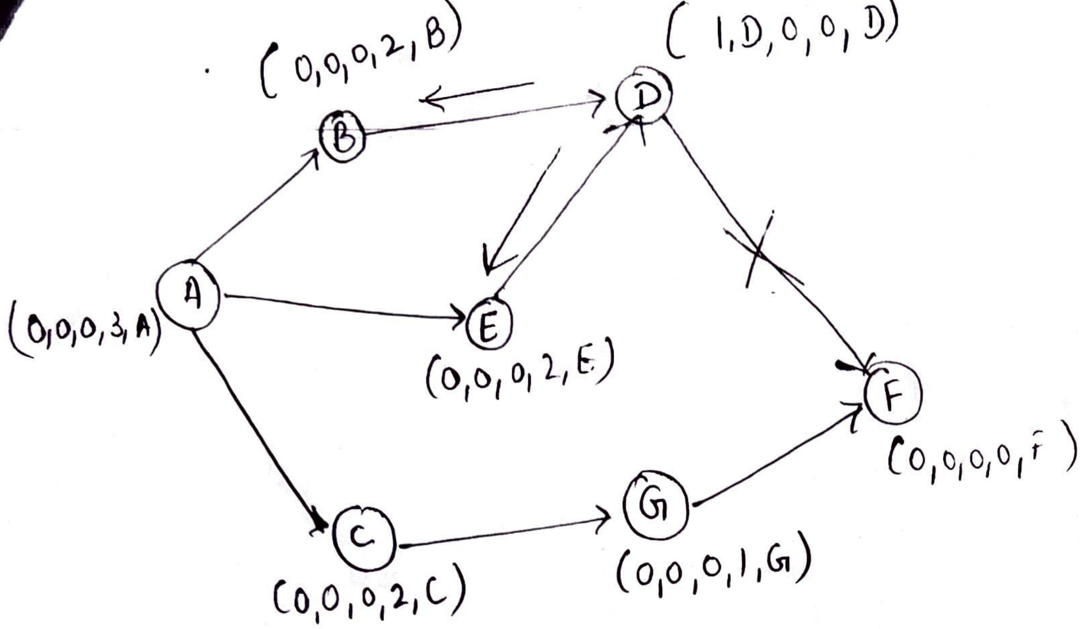
Case 1: link is broken and every node in network has a downstream link, No action is required.



Assume link between E & G is broken.

Case 2: Link is broken and node in network don't have any downstream link, Create a new reference level and send it to neighbors

(Old-ref +1, <node-id>, 0, <node-id>)



Assume link between D & F is failed.

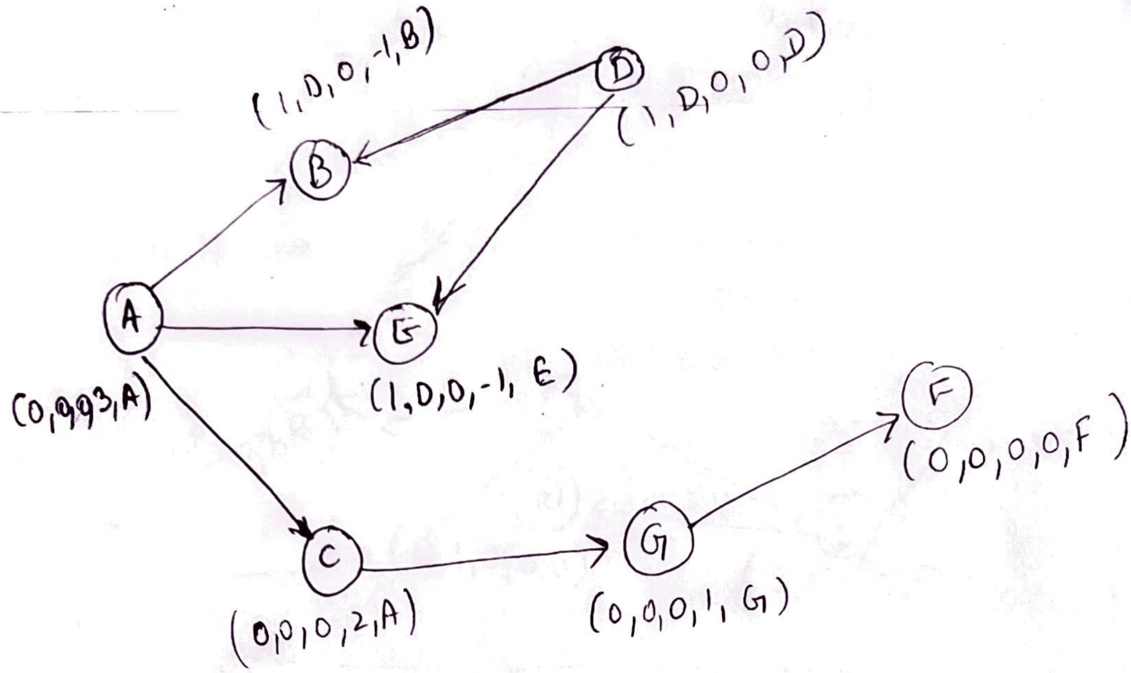
Node B & E receive UPD packet with height information.
Height of D is greater than their current height so link direction will be changed.

Case 3: Propagate

Node in network don't have any downstream link because of route maintainance process.

Compare neighbour's reference level, if it's not same then take highest reference level.

(<reference of highest node>, That node order-1, node-id)



B & E update their height
They are having information of A's height with first value 0 considered low height.

LOCATION AIDED ROUTING (LAR)

- LAR uses location information using GPS (Global positioning system) through which every node can know it's current physical location.

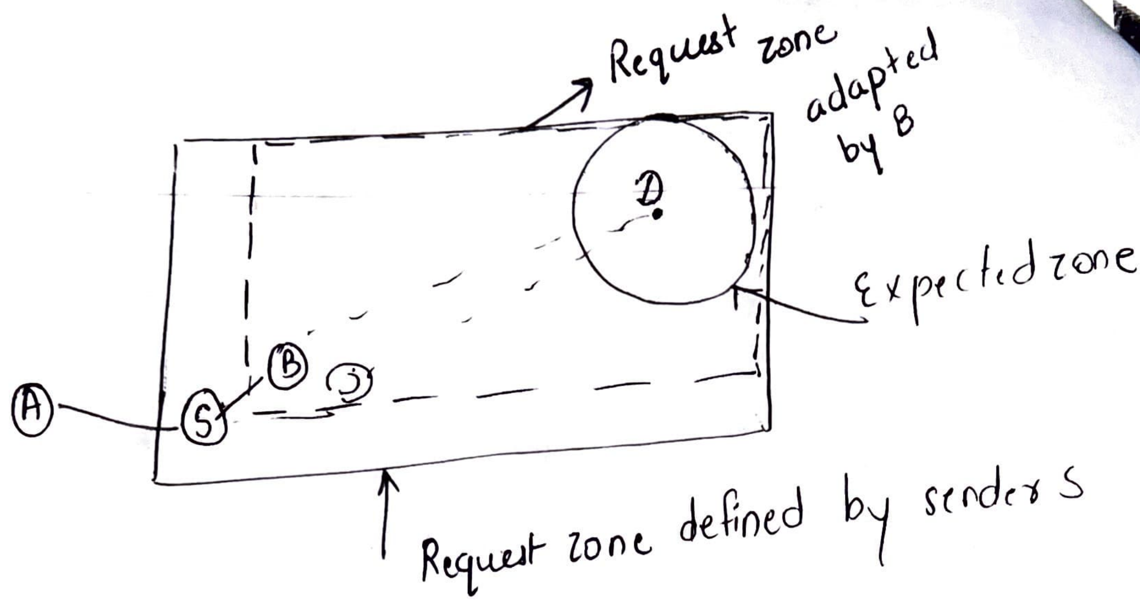
- In LAR node find out route to another node when it wants to send data to that node
  - → Route Discovery
  - → Route Error

- LAR is on demand routing protocol. It uses variation of flooding.

- LAR designates two geographical regions
  - Expected Zone
  - Request Zone

Expected Zone : is determined as a region that is expected to hold the current location of the destination

Request Zone : Route requests limited to a request zone that contains the expected zone and location of the sender node.
Only nodes within the request zone forward route requests.



- Request zone explicitly specified in the route request.
- Each node must know its physical location to determine whether it is within the request zone
- If route discovery using the smaller request zone fails to find a route, the sender initiates another route discovery using a larger request zone.

Rest of route discovery similar to DSR.

Advantages :

1, Reduces the scope of route request flood.
2 reduces overhead of route discovery.

Disadvantages :

1. Nodes need to know their physical locations
2. Doesnot take into account possible existence of obstructions for radio transmissions.

Zone Routing Protocol

(ZRP)

- ZRP is a hybrid protocol.

Proactive (Intra zone RP) — Reactive (Interzone Routing Protocol)

- Using best part of proactive and reactive routing protocols.
- Zone is based on the radius / no. of hops

↳ Intrazone (IARP)

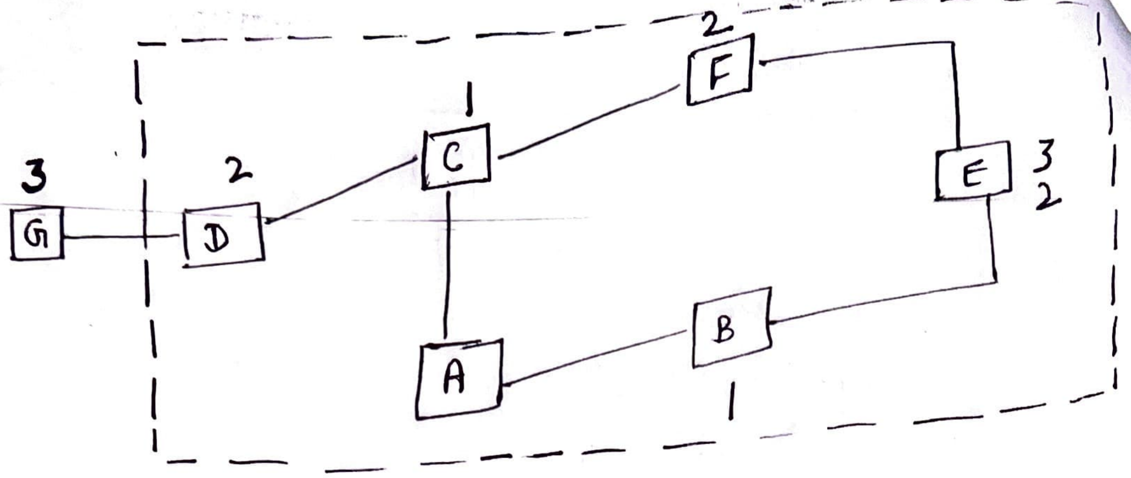
Used for maintain route in zone using proactive routing.

↳ Inter Zone (IERP)

Help to find route to nodes outside of zone, reactive routing protocols used.

- Routing zone of a node X includes nodes which have minimum distance in hops from X is atmost pre-defined number known as zone radius.

→ Zone is defined for each node separately.



Routing zone of node A with zone radius 2

Pheripheral Nodes → D, E, F (nodes having distance equal to zone radius)

Step 1: Node A will check whether destination is in its zone or not.

Step 2: If destination is in zone then node A must be having route to destination (Proactive)

Step 3: If destination is not in zone then Node A send a route query to its peripheral nodes

Step 4: When peripheral node receive route query packet then it also run same logic. It will check whether destination is in their zone or not.

Route Accumulation process :

A node appends its IP address to a received query packet. The sequence of IP addresses specifies a route from the query's source to the current node.

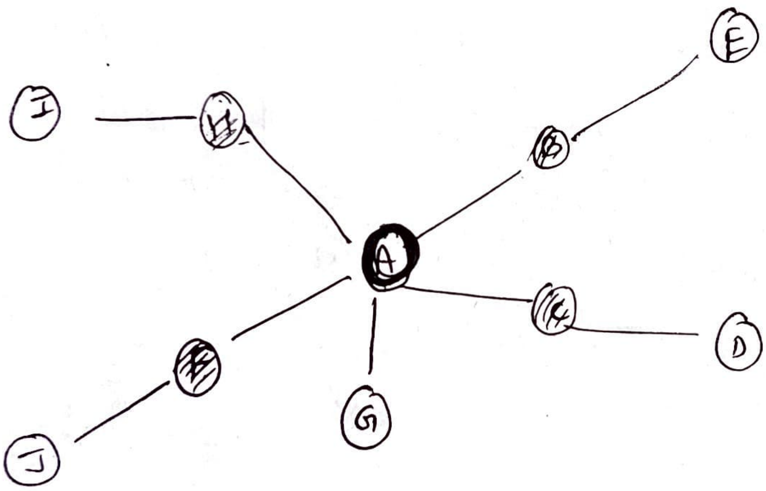
7

(Proactive – Table driven)

OLSR

Optimized Link State Routing protocol

- Extension of LSR
- Avoid unnecessary trans* of LS packet.
- Each node decides MPR (multi point relay)
  ↓ Futher rebroadcast
- Only MPR can retransmit, others don't.



- MPR (H, F, B, C) ⟶ affects the performance of OLSR.
  Node which is selected by its 1 hop neighbour to retransmit all broadcast message received by it.

- Types of packets.
  1. HELLO pkt (used to sense neighbours) → received by all one-hop neighbours.
  2. Topology control pkt (Tell another nodes what are MPR of the nodes)
     ↳ Topology information.
  3. MID pkt →

On receiving HELLO msg

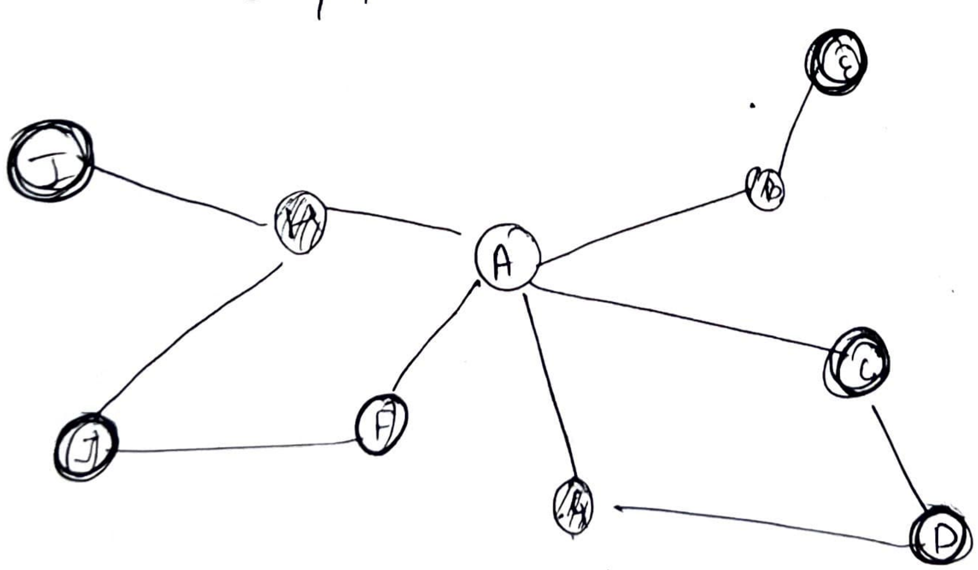
→ Each node constructs its MPR Selector table

↳ 2 hop neighbour] Based on this, they
↳ 1 hop "] select MPR node.

MPR selection Algorithm [select $N_1(u)$, $N_2(u)$].

Step 1: Select node of $N_1(u)$ which cover isolated points of $N_2(u)$.

Step 2: Select among the nodes of $N_1(u)$ not selected at the first step, the node which covers the highest no. of points of $N_2(u)$ and go on till every point of $N_2(u)$ are covered.



At Node A

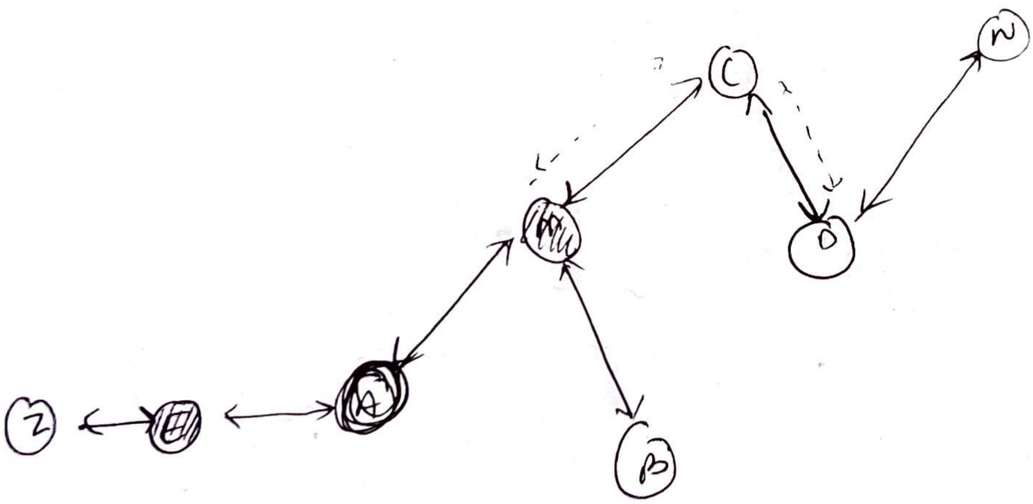
MPR : H, G, B

A : multi point relay selector.

Eg: OLSR Routing

Node A

Dest Add	Dest MPR	MPR selector seq.
B	m	1
C	m	1
D	C	2
Z	E	2
N	D	2



Node A wants to send to D

A will send to A → m → C → D

Types of Routing Protocols

| Based on Routing info^n update

Proactive

(Table driven Routing)

- Each node maintain a routing table
- → when node need path they run path finding algorithm acc to topology

eg
- ↳ DSDV ✓
- STAR
- CGSR ✓

Reactive

(on-demand Routing)

- → no node maintain a routing table
- → They obtain necessary path when required
- → eg
  - DSR ✓
  - ↳ AODV ✓

Hybrid

- → Combination of Both
- → N/W is divided into zone

eg ZRP

zone
- within ↓ Proactive
- Beyond ↓ Reactive

Based on Temporal information for Routing

- Past Temporal History
  - eg → DSDV, AODV
- Future Temporal
  - ↳ LLBR

Based on Routing Topology

- → Flat Topology → DSR [use flat addressing scheme
- → Hierarchical Topology → CGSR [use logical addressing scheme

Based on utilization of specific Resources

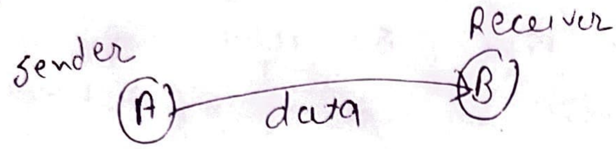
Power Aware Routing → Minimum Power

Geographical info^n assisted Routing :- they improve performance ↑ Control overhead ↓ by using Geographic info^n

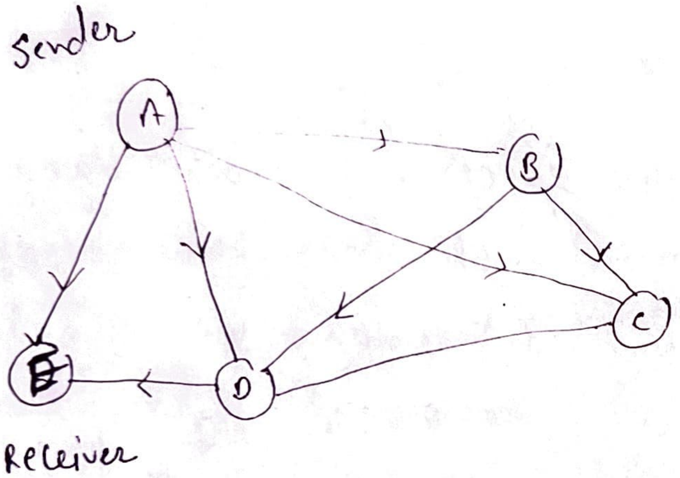
Unit-2

Routing Protocol -

Routing is the process of establishing a path b/w the sender & Receiver nodes for transmitting the packet along the path



Direct Path



- RP will find the best optimum path (shortest Path

A → B → C - D → E
A → D → E
A → B → D → E
A → C → D → E
A → E

(A → E)

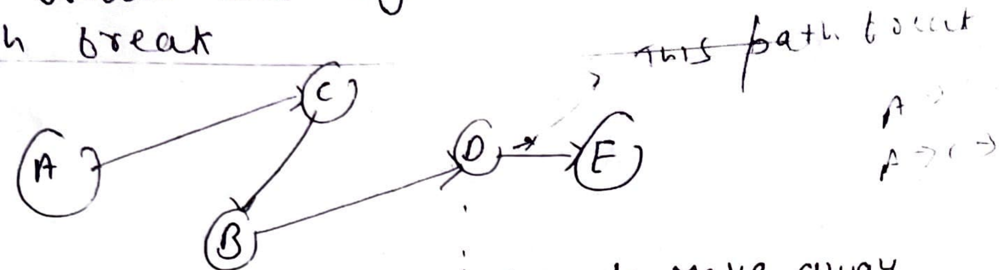
Design Constraints

Node Mobility
- Dynamic topology
- No Centralised infrastrure [biggest Constraint]
- Bandwidth
- Energy (battery life)
- End to End path

Designing Routing Protocol

Node Mobility

Nodes are dynamic → due to which frequent path break



* Designing should be like, so that we can consider these type of scenario & delay should be minimum.

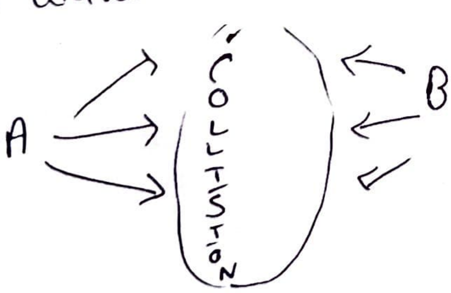
2 Bandwidth Constraint

→ Due to limited Radio spectrum [Low B/W] data rates it can offer are much less than wired.

→ due to dynamic change in topoloy, we should maintain a consistent topological information at a node, which involves more control overhead which results B/W wastage.

3 Error-prone Shared broadcast Channel

A want to send data, so they will broadcast



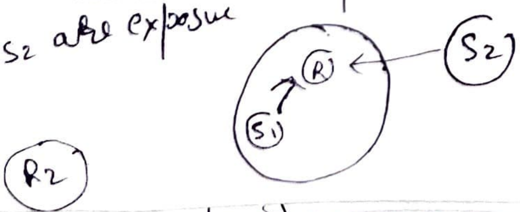
Collision generate Error [hidden Terminal Problem]

→ R.P find path with less Congestion

4 Hidden & Exposed Terminal Problem

S_1 & S_2 are exposure

Collision at R_1 (S_1 & S_2 are hidden)



ource Constraint.

- Limited battery Power
- Processing Power
- memory & energy limited.

6. ## Security Issue.

→ no centralised secure serve
→ so we can't use security Protocol

Snooping. DOS

(a). sense the entry of enemy

enemy Territory Area [Border

Characteristics

1. Must be fully distributed [It involve single point failure]
   ↳ less Control overhead as Compare to centralized
2. Adaptive to topology change
3. Packet Collision should be minimum
   ↳ limiting no of broadcasts
4. optimal route
5. It should provide Qos at certain level
6. Route Computation & maintainance must involve minimum node
7. It must be localized
8. It must optimally used resources like B/w, m/m, Power

ntade & Disadvantage

1) Proactive

Adv :- Minimum time to find path

Dis :- periodically infoⁿ exchange required
- High N/W overhead
- High B/W Consumption
- Not Suited for large N/W

2) Reactive

Adv :- - less broadcast Control msg required
- low N/W overhead
- low b/w wastage
- Suitable for large N/W

Dis - Time to discover route is non-predictable

3) Hybrid

Adv :- Require less m/mt Processing power
- Advantage of both reactive & proactive protocol

Dis :- If border node move away path takes re-establishment away. long time

1) Destination Sequenced Distance vector (DSDV) ①

flat topology

vector Routing : In this each node keeps record of route info^n in the form of routing table.

Table Consist of

- → Dest^n id
- → next node
- → Distance (no of hops Required)
- → Sequence No

• Based on Bellman ford algorithm

• Periodically broadcast routing updates

Route broadcast msg :

- → Dest^n node
- → next hop
- → Recent sequence no
- → Distance [No. of hops required]

Routing Table of N1

Dest^n	Next node	dist.	Sequence no
N2	N2	1	14
N3	N2	2	18

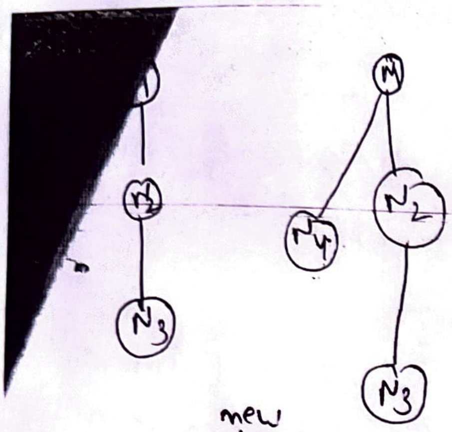
Sequence no → use for Route maintainance

→ Arbitary No

Each node exchange its updated Routing table with each other

update

- multiple n/w data packet unit → Full Dump: entire Routing table is send to neighbour
- Single n/w Data packet unit → Incremental update: only entries that are change are exchange



new node N_4

Destn	next node	dist	seq no
N2	N2	1	14
N3	N2	2	18
N4	N4	1	22

* In Incremental only update entry of N4 is exchange
* In full Dump whole table is exchange

Table Maintance in DSDV :-

→ Each node receive the route infoⁿ with most recent seq no from other node & update its table

→ Node looks at its routing table in order to determine shortest path to reach all the destination

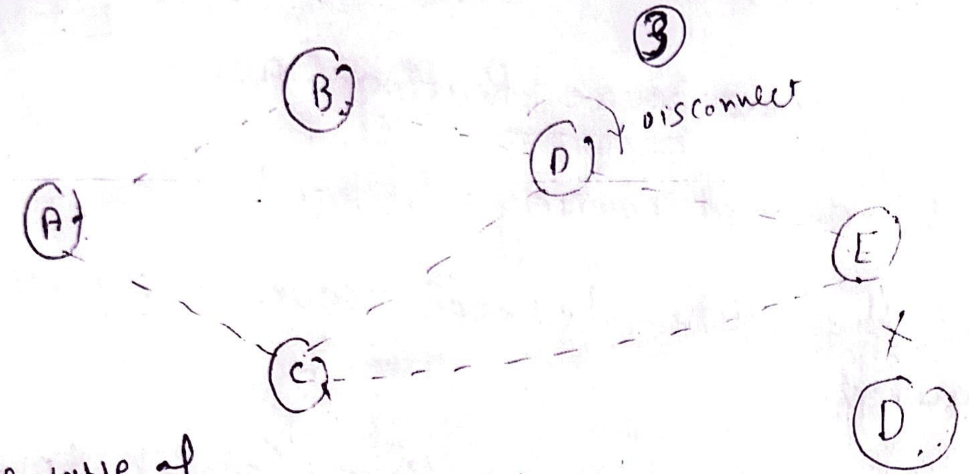
→ Each node construct another routing table based on shortest path infoⁿ

→ New Routing table will be broadcast to its neighbour.

→ Neighbour nodes update its routing table

②

③



Routing table of

Node A

Dest^n	nexthop	Distance	Seq no
B	B	1	340
C	C	1	164
D	B	2 ∞	114 → Discarded
E	C	2	20
D	C	3	124 → New entry

If node D is disconnect

→ Distance of D is ∞ & broadcast it to all

After some time D Join

D previous entry is Discarded & new entry will make

→ New sequence no should be greater than previous so then it will consider.

II

(5)

Dynamic Source Routing (DSR)

On-demand routing Protocol.

↳ discovers the route between source and destination when required.

↳ Oprⁿ is based on source routing (sender knows the complete path.)

↳ Intermediate nodes donot maintain routing infoⁿ to route the packets to the destination.

↳ Network overhead is less as the no. of message exchanges b/w nodes is very low.

HELLO packets : are used to inform neighbours about existence of the node.

Note: DSR doesnot use HELLO pkts.

- DSR floods route request (RREQ) packet in the n/w
  Destination node replies with route reply packet (RREP)

RREP packet contains the path traversed by RREQ.
Receiver responds only if this is a first route request (not duplicate).

quence Numbers are used to prevent loop formation

& ~~nodes check it~~. to avoid multiple transmissions

RREQ carries the ~~path traversal~~ and the sequence number.

at intermediate nodes

Route Cache : If node has a route in the cache, this route is used. It is also used in route construction phase.

Phases of DSR

Route Discovery
↳ RREQ (Route Request)
↳ RREP (Route Reply)

Route Maintenance
↳ RERR (Route Error)

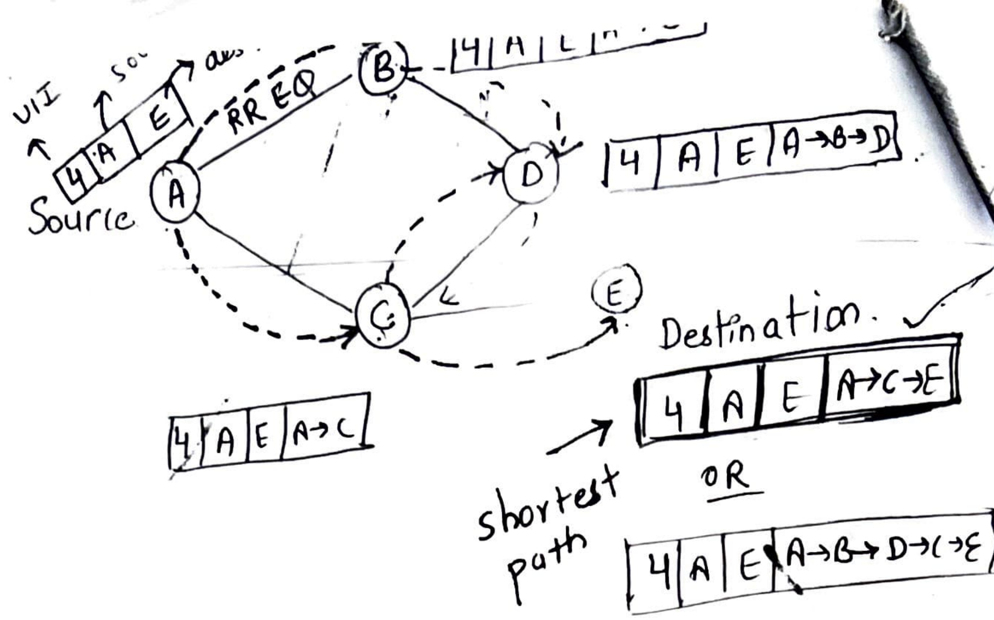
In Route Discovery, 2 diff packets are used. Route Request packet and another is Route Reply packet.

Destination send RREP packet with a complete path to the sender where RREP is unicast & RREQ is broadcast.

Route Maintenance is similar to all adhoc n/w. It contains Route Error message. If there is any link breakage then it sends their information to all its neighbour nodes.

→ RREQ includes destination address, source address & a unique identification No.

Example of DSR :



∴ A wants to send data to E

RREP : E → C → A

A send route request packet to B & C.
Now B & C checks either they are destination Id's or not.
If they are destination, then they send RREP packet
if they are not destination node then they update the packet.

Now B send RREQ to D & C send to D & E.
When B send RREQ then C send to D. C checks that it already reach D, than it discard to D.
& C send RREQ to E

Suppose if RREQ follow A→B→D→C→E then

| 4 | A | E | A→B→D→C→E | discard X

Consider optimum path

| 4 | A | E | A→C→E |

Now, path is decided. Now E will reply RREP to C then to A. A will have packet | 4 | A | E | A→C→E | and path to reach to E

Advantage of DSR :

→ Uses a reactive approach which eliminates the need to periodically flood the n/w with table update messages which are required in table-driven approach.

→ Intermediate node also utilize the route cache information efficiently to reduce the control overhead.

Disadvantage :

→ Routing overhead is involved due to source-routing mechanism employed in DSR.

→ This routing overhead is directly proportional to the path length.